W. L. Wharton, Esq. Communicated by James F. W. Johnston, Esq., M.A., F.R.S. L. & Ed.

The author, considering the generally received explanation of intermitting springs, founded on the operation of a simple syphon, as being insufficient to account for the phænomena, inasmuch as the water which has risen above the lower side of the bend of the syphon will merely trickle down its longer leg, and be expended before it can fill the whole area of that part of the syphon, has proposed the following hypothesis for the solution of the difficulty. He conceives that the stream, while falling obliquely down the long leg of the syphon, is broken into drops, and carries along with it numerous air-bubbles, which, if the lower end of the tube have an abrupt bend upwards, will be impelled forwards, and escape at the open part; thus occasioning a rarefaction of the remaining air in the tube sufficient to ensure its full operation as a syphon. A model is described, which the author constructed for the purpose of illustrating and corroborating his views.

January 25, 1838.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

Neil Arnott, M.D.; the Rev. William Cureton, M.A.; and Charles Lock Eastlake, Esq., were severally elected Fellows of the Society.

A paper was in part read, entitled, "Fourth Letter on Voltaic Combinations." Addressed to Michael Faraday, Esq., D.C.L., F.R.S., by John Frederic Daniell, Esq., F.R.S.

February 1, 1838.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

The reading of a paper, entitled "Fourth Letter on Voltaic Combinations, with reference to the mutual relations of the generating and conducting surfaces;" addressed to Michael Faraday, Esq., D.C.L., F.R.S., &c. By John Frederic Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London, was resumed and concluded.

In this communication the author describes a series of experiments, made for the purpose of determining the distribution of the voltaic force from its source in the generating metal, as indicated by the deposition of reduced copper in the constant battery; and, considering that the voltaic combination most perfect in theory would be one formed by a solid sphere, or point, of the generating metal, surrounded by a hollow sphere of the conducting metal, with an intervening liquid electrolyte, he constructed an apparatus making as near an approximation as possible to these conditions. It consisted of two hollow brass hemispheres, applied to each other by exterior

flanges, and rendered water-tight by an intervening collar of leather. In the centre of the hollow sphere thus formed, a ball of amalgamated zinc was suspended by a well-varnished copper wire, connected with one of the cups of a galvanometer, and was contained in a membranous bag holding the acid solution; the whole being introduced through a short tube in the top of the upper hemisphere, and the remaining space being filled with a saturated solution of sulphate of copper. The galvanic circuit was completed by wires establishing connexions between either hemisphere and the other cup of the galvanometer. For measuring the forces developed, sometimes the ordinary magnetic, but in the greater number of instances the calorific galvanometer of De la Rive was employed; the indications given by these instruments were noted, on the completion of the circuit, in various ways; and the deposition of copper in the hemispheres was examined after the apparatus had been in action for a certain number of hours.

The following are the conclusions which the author deduced from a series of experiments thus conducted:

1st. The force emanating from the active zinc centre diffuses itself over every part of the upper hemisphere, from which there is a good conducting passage for its circulation.

2nd. The same amount of force is maintained by either hemisphere indifferently; but when both conducting hemispheres are in metallic communication there is no increase of force.

3rd. Although the force is not increased, it spreads itself equally over the whole sphere.

4th. When one hemisphere is connected with the zinc centre by a short wire capable of affording circulation to the whole force, and the other hemisphere is connected by a long wire, through the galvanometer, with the same centre, the equal diffusion of the force over the whole sphere is maintained.

5th. There is no greater accumulation of precipitated copper about the point with which the conducting wires are brought into contact, and towards which the force diffused over the whole sphere must converge, than at any other point: proving that the force must diverge from the centre equally through the electrolyte, and can only have drawn towards the conducting wires in the conducting sphere itself. Other experiments showed that the force is but slightly increased by a great increase of the generating surface.

The author's attention was next directed to ascertaining the nature of the law according to which the force emanates from the zinc centre to the surrounding conducting sphere. With this view, a variety of experiments were made with the zinc in different positions in the interior of the sphere; and from these it appeared that, whatever may be its position, the whole force is the same. From these results it is inferred, that the force emanating from the zinc ball diffuses itself over the surrounding conducting sphere in obedience to the well-known law of radiant forces being in the inverse duplicate ratio of the distance.

Experiments of the same kind were likewise made with the pre-

vious combination inverted, that is, with a small copper ball in the interior of a large hollow sphere of zinc; and from these the author concludes that, in this case also, the law of radiation is maintained, although the force is reduced to one half of that obtained from the former combination.

In order to ascertain the effect of cutting off the lateral radiation from the zinc ball, it was placed in a glass tube, six inches long, within half an inch of the lower aperture, over which a piece of membrane was tied, and the tube plunged into the solution of copper contained in a brass hemisphere, so as to rest upon the bottom. The results obtained by this arrangement, as also those when the zinc ball was raised in the tube to the surface of the solution, showed that the action of the zinc ball had been propagated from the aperture of the glass tube, as from a centre, diverging from this in the solution.

The experiments next described appear to have an important bearing on a question of vital interest in the theory of electricity, which has been discussed by Mr. Faraday, in a paper recently read to this Society: viz., whether the forces emanating from a centre of electric action act, like other central forces, in straight lines; or whether they are propagated from particle to particle in the surrounding matter, and may, consequently, when obstacles interfere with their rectilinear propagation, exert their influence in curved lines. An elliptical plate of copper, one side of which was covered with lac varnish, was placed in an earthen pan, with the varnished side upwards, and covered to the depth of a few inches with the acid solution of copper. The zinc ball, placed in the tube half an inch from the diaphragm, was plunged just below the surface of the solution, and the circuit being completed, the galvanometer indicated an action nearly equal to that which had been previously observed when both sides of the copper had been exposed. The under side of the copper presented the appearance of a border of precipitated compact pink copper, varying from $1\frac{1}{2}$ to $\frac{7}{8}$ of an inch in width, and the remainder was covered with precipitated copper of a darker red colour, into which the border gradually passed; and similar results were obtained with a circular disc of copper, having one side varnished. It hence appears, that the under surface, which, by itself, is capable of sustaining from the ball in the centre of the solution an action nearly as great as the upper surface, when combined with the latter adds no more than about one-eighth part of its efficiency; and whereas, with the upper surface, the action varies in some inverse ratio of the distance of the generating from the conducting surface, with the under surface, there is a maximum point, on both sides of which it decreases: and this point is doubtless dependent on the angle at which the force which radiates from the ball meets the edge of the plate. The author having been led to the conclusion, that the force developed by voltaic combinations is subject to the law of radiant forces, had been utterly at a loss to understand how, upon this hypothesis, it could extend its influence to the side of a plate opposite to that to which it was directed in right lines; but having perused Mr. Faraday's "Eleventh series of experimental researches in

Electricity," all his own results appeared to fall in naturally with the general views therein explained. He considers, that the direction of the force through an electrolyte may be expressed in the very words employed in that paper to describe that of the direct inductive force in statical electricity, simply substituting the term *Electrolyte* for *Dielectric*, and the term *Current* for *Induction*.

Experiments are further described, in which the effects of various combinations of different generating and conducting surfaces, placed at different distances apart, were measured by the calorific galvanometer, from which the following conclusions are drawn:

1st. That the energy of the force is about sextupled by the absorption of the hydrogen at the conducting surface; except in the case of equal plates, when it is more than quadrupled.

2nd. That the effect of distance is much more decided in the instances where the amount of the circulating force is greater, than in the contrary cases.

3rd. That the amount of force put into circulation from a large surface of zinc towards a central ball of copper, is, as in former instances of similar combinations, about one half of that from the reverse arrangement.

4th. That a ball of zinc, exposing a surface of 3·14 square inches, placed over the centre of a plate of copper, exposing on its two sides a surface of 28 square inches, sustains an action of nearly the same amount as a plate of zinc, of the same dimensions as the copper, placed at the same distance.

In conclusion, the author remarks, that the principal circumstance which limits the power of an active point within a conducting sphere, in any given electrolyte, is the resistance of that electrolyte, which increases in a certain ratio to its depth or thickness; and this thickness may virtually be considered the same wherever the included point may be placed, but increases with the diameter of the sphere. In an insulated hemisphere, however, the approximation of the active point to the lower surface virtually decreases the thickness of the electrolyte, and consequently the force increases. In this respect, the action of a point upon a plate may be considered the same as upon an indefinitely large hemisphere, towards which, as the point approaches, the force increases.

February 8, 1838.

STEPHEN PETER RIGAUD, Esq., Vice-President, in the Chair.

George Lowe, Esq., who, at the Anniversary of 1836, had ceased to be a Fellow, from the non-payment of his annual contributions, was, at this meeting, re-admitted by ballot into the Society, agreeably to the provision of the Statutes.

James Bateman, Esq.; Joseph Glynn, Esq.; William Hallows Miller, Esq., M.A.; the Rev. Joseph Bancroft Reade, M.A.; Robert Bentley Todd, M.D.; and Alexander Tweedie, M.D., were elected Fellows.